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A new species of *Chilotherium* (Perissodactyla, Rhinocerotidae) from the Late Miocene of Qingyang, Gansu, China

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Abstract An adult skull with articulated atlas and an adult mandible, collected by Emile Licent in 1920 from the Late Miocene of Qingyang (Gansu, China), is recognized as a new species *Chilotherium licenti* sp. nov. These specimens possess typical characters of the genus *Chilotherium*, such as the strongly expanded mandibular symphysis, the huge and dagger-shaped i2s with an upturned medial flange, strongly constricted protocones, well-developed crochet and crista, and weakly developed parastyle folds and paracone ribs. *Chilotherium licenti* is characterized by the near absence of lingual and buccal cingula, and the medifossette on P2 to M2 forming by well-developed crochet and crista. The derived characters of the new species indicate that it is the highly specialized taxon of the genus *Chilotherium*, corresponding to MN12–13 of the Turolian in Europe. Based on a phylogenetic analysis of rhinocerotids, *C. licenti* from the Late Miocene is the most derived species in the known species of the *Chilotherium* lineage.

Key words Qingyang, Gansu; Late Miocene; Rhinocerotidae, *Chilotherium*

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1 Introduction

Emile Licent, a French Jesuit and naturalist, collected abundant fossils of the *Hipparion* fauna in 1920 in Qingyang, Gansu Province, China (Licent, 1936), but among those fossil collections, only the hyaenids (Qiu et al., 1979) and *Hipparion* (Qiu et al., 1987) have been systematically studied. *Chilotherium* is one of the most common genera in the *Hipparion* fauna in China, and it is particularly common in the fossil sites at Baode, Fugu, and Linxia (Deng, 2002). However, there are no detailed reports about the *Chilotherium* from Qingyang. Here we

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studied the rhinocerotid fossils collected by Licent nearly 100 years ago from Zhaojiacha (Tchao kia tch'a), a small village in Qingyang, Gansu (Fig. 1).

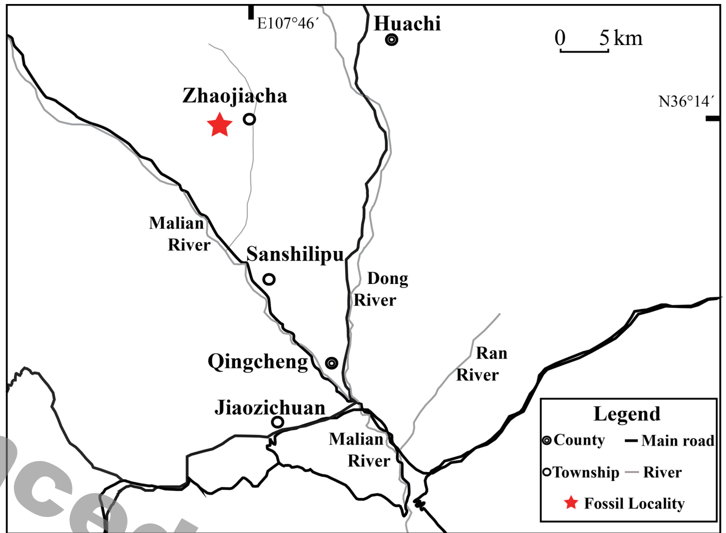

Fig. 1 Map of the Zhaojiacha locality, Qingyang, China

Since Ringström (1924) established the genus *Chilotherium*, 13 species have been described, and 19 other species have been referred to this genus. According to Deng (2006), there are ten valid species at present, i.e. *C. primigenius*, *C. anderssoni*, *C. habereri*, *C. wimani* and *C. xizangensis* from China; *C. schlosseri*, *C. samium*, *C. kowalevskii* and *C. kiliasi* from Europe; and *C. persiae* from Iran. The material examined and described here is a new derived species that can be regarded as a new species of *Chilotherium*, which indicates a higher evolutionary level and expands adaptation of the genus.

The materials studied here consist of one skull (TNP 03978) articulated with its atlas and one mandible (TNP 00328) housed in the Tianjin Natural History Museum. The osteological terms were according to Sisson (1953) and dental terms were adopted from Qiu and Wang (2007). The specimens were measured according to the methods used by Guérin (1980). An analysis was carried out using the craniodental data matrix of Antoine (2002), Antoine et al. (2003, 2010) and Lu (2013).

2 Systematic paleontology

Family Rhinocerotidae Owen, 1845

Subfamily Aceratheriinae Dollo, 1885

Tribe Chilotheriini Qiu et al., 1987

Genus *Chilotherium* Ringström, 1924

***Chilotherium licenti* sp. nov.**

(Figs. 2–5)

Holotype TNP 03978, a well-preserved adult skull with articulated atlas, lacking the

premaxilla and occiput.

Referred specimen TNP 00328, lower cheek teeth and i2s in situ, but most part of the mandibular body was broken off.

Etymology The specific name '*licenti*' is named after Emile Licent, the French Jesuit and naturalist who collected the specimens.

Type locality Zhaojiacha (36°14′52.2″N, 107°46′31.3″E; elevation: 1168 m), Huachi County, about 60 km northeast to the Qingyang City in Gansu Province, China (Fig. 1). The specimens were collected from a brownish red mudstone containing caliche nodules that is within the *Hipparion* Red Clay. The fossil-bearing bed is late Late Miocene in age (the Baodean Asian Land Mammal Age).

Diagnosis Wide nasals become narrow gradually before the orbits; the zygomatic arch is fairly thin, particular in its posterior part; protocones and hypocones are strongly constricted, with straight lingual margins; crochet and crista are well developed and link together to form a medifossette on P2–M2, and antecrochet is also well developed; M1 has a projecting parastyle; lingual and buccal cingula are nearly absent; the buccal wall on the upper premolars and M1 is straight and smooth; the posterior valleys of the upper cheek teeth are almost closed.

3 Description

Skull TNP 03978 is well preserved except for the premaxilla and occiput (Fig. 2). The cranial height is 117 mm in front of M3. In dorsal view, the widest portion in transverse direction of the cranium is at the level of the postorbital process. The nasals are wide and particularly long (more than 81.3 mm), and there is a fine longitudinal groove along the marked sagittal suture. The top surface of the nasals is smooth without any rugosity. The lateral margins of the nasals do not have obviously downturned edges, and their transverse section is half-lentoid. The nasals become narrow gradually before the orbits, i.e., the nasal base does not have a constriction. The tips of the nasals are evidently truncated, which is located before the level of DP1. The nasal notch is V-shaped (narrow and deep), and its posterior edge is located at the level of M1/P4 boundary. The distance between the posterior edge of the nasal notch and the orbit is 72.2 mm. There are two infraorbital foramina. One is located dorsal to the level of M1 and near the lateral margin of the nasal notch, and the other one is near the inferior margin of the nasal notch. The position of the dorsal margin of the orbit is high, and the anterior margin of the orbit is located at the anteroposterior plane of the middle of M2. The zygomatic arch is fairly thin (particularly its posterior part), the anterior end of which is located at the level of M2 and the dorsal margin is curved. The dorsoventral height of the zygomatic arch is 54.9 mm at the anteroposterior level of the postorbital process. The postorbital processes on the frontal and zygomatic bones are comparatively weak. The palatal surface is smooth and widely arched. The basicranium part is poorly preserved. The postglenoid process is broken, only the base perseved. The temporal condyle is flat and straight. The glenoid cavity is deep. The occipital crest is

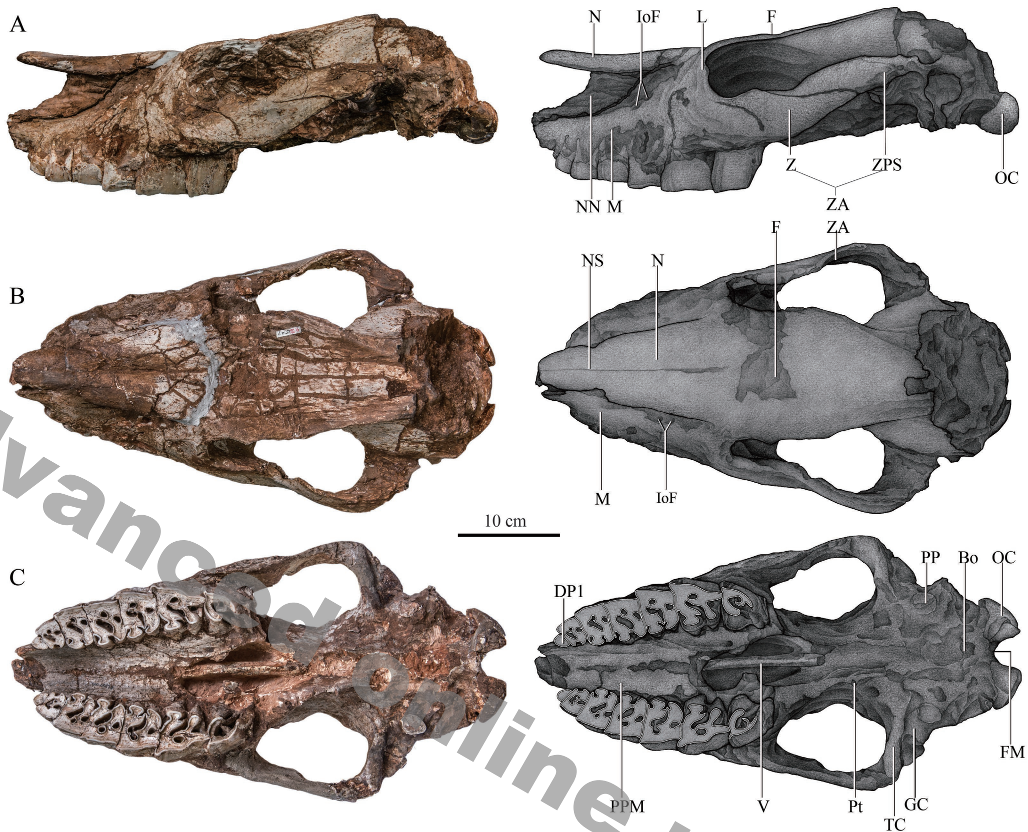

Fig. 2 Photographs and sketches of the skull of *Chilotherium licenti* sp. nov., holotype (TNP 03978)
A. lateral view; B. dorsal view; C. ventral view
Bo. basioccipital; DP1.upper first premolar; F. frontal; FM. foramen magnum; GC. glenoid cavity; IoF. infraorbital foramen; L. lacrimal; M. maxilla; N. nasals; NN. nasal notch; NS. nasal suture; OC. occipital condyle; PP. postglenoid process; PPM. palatine process of maxilla; Pt. pterygoid; TC. temporal condyle; V. vomer; Z. zygomatic; ZA. zygomatic arch; ZPS. zygomatic process of the squamosal.

broken. The foramen magnum is onion-shaped, with a pointed upper end. The premaxilla is missing. So it cannot be determined whether or not there was any upper incisor. However, as a member of the genus *Chilotherium*, its upper incisors were probably reduced or lost.

Atlas The fragmentary atlas is articulated with the skull, and lacks the wings and the caudal part (Fig. 3). The outline of the neural canal is mushroom-like. Alar notches are present. The cranial articular fovea is comma-shaped in outline. The centrum of atlas is intact, i.e., the anterior part of axis dens is preserved.

Upper cheek teeth The premolars (with the exception of DP1) and M1–2 are moderately worn, but M3 is only slightly worn, which are hypsodont (Fig. 4A). The upper cheek teeth row is almost in a straight line located in the anterior portion of the cranium relative to the orbit. The ratio of the length of upper premolars (P3–4) to the molars (M1–3) is large, 85.2%. The cement on the buccal surface of upper cheek teeth is moderately developed. On the premolars and M1, the buccal wall is straight and smooth. On the molars, the protocone is strongly constricted, and

its lingual margin is straight.

DP1 is fairly small and shows a round triangle in shape. It is deeply worn.

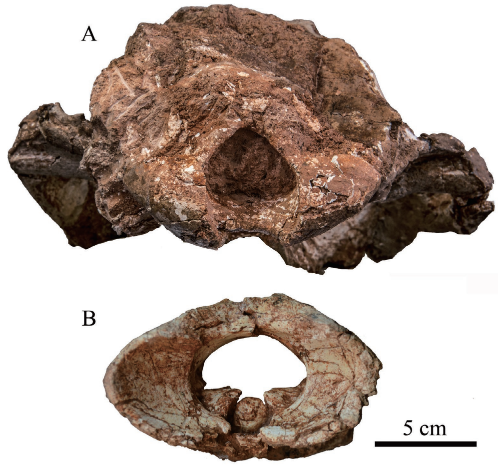

Fig. 3 Skull (A) and atlas (B) of *Chilotherium licenti* sp. nov. (TNP 03978)
A. occipital view; B. anterior view

The outline of P2 is nearly quadrangular in occlusal view with a parastyle and fairly weak parastyle fold. The protocone and the hypocone have no constriction, and they connect to each other by a bridge. The hypocone is larger than the protocone. The hypocone is in the posterior direction of the metacone. The protoloph is as buccally narrow as the metaloph, and joins with the ectoloph. The crochet and crista are well-developed and link together to form a medifossette. The lingual groove is shallowly U-shaped. The medial valley is closed and the posterior valley is nearly closed. The lingual cingulum is weak, and the buccal cingulum is absent.

P3 has a slightly projecting parastyle, with a weak parastyle fold and paracone rib. As a result, the buccal wall is straight and smooth. The protocone is expanded, with anterior and posterior constrictions, and the hypocone only has slight anterior constriction. The protocone and hypocone connect with each other by a bridge. The protocone is larger than the hypocone. The crochet and crista are well-developed and link together to form a medifossette. The lingual groove on the protocone is present. The medial and posterior valleys are closed. The lingual margin of the protocone is curved. The lingual and buccal cingula are absent.

P4 is similar to P3, but much larger. The hypocone is rounded, without any constriction. The hypocone is slightly larger than the protocone. The lingual margin of the protocone is straight.

M1 has a projecting parastyle. Its strongly constricted protocone has a flat lingual margin, and the hypocone only has a slight anterior constriction. The medial valley is narrow, and the

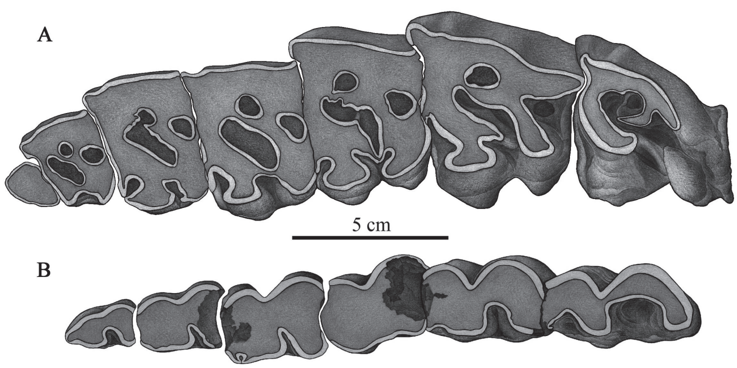

Fig. 4 Sketch of the teeth of *Chilotherium licenti* sp. nov. (TNP 03978) in occlusal view
A. left upper cheek teeth (DP1–M3); B. right lower cheek teeth (p2–m3)

sharp end of a fine antecrochet extends to the entrance of the medial valley. The crochet and crista of the right M1 are well-developed, but do not link together to develop a medifossette. The posterior valley is triangular in shape and nearly closed. The crochet and crista of the left M1 link together to develop a medifossette. The lingual and buccal cingula are absent.

M2 has a narrow and long parastyle and a weakly developed paracone rib. It has slightly developed anterior and posterior cingula but no lingual cingulum. The protocone is expanded, with anterior and posterior constrictions. In occlusal view, the small hypocone does not have a constriction, but it has a vertical constricted groove on the anterior aspect. It has a medifossette, open medial valley, V-shaped posterior valley, relatively narrow and long metastyle, and deep depression on the buccal wall of the metacone.

M3 is triangular in occlusal view because the ectoloph and metaloph are fused. It has a short and sharp parastyle, narrow protoloph, and ectometaloph. In the right M3, the hypocone is isolated, not linking to the ectometaloph. The protoloph is curved on the antero-lingual side. The crochet is well-developed, but does not form a medifossette. The protocone has anterior and posterior constrictions. The posterior cingulum is well developed.

Mandible TNP 00328, lower cheek teeth and i2s in situ, but most part of the mandibular body was broken off (Fig. 5). In dorsal view, the mandibular symphysis expands strongly laterally. In anterior view, the incisor alveolar margin is thin and sharp.

Lower teeth The premolars and m1–2 are deeply worn, and the m3 is moderately worn (Fig. 4B). The paraconid and paralophid are not developed. The constrictions of the metaconid and entoconid are absent. The ectoflexid deepens gradually from the base to the crown. The cement on the buccal surface of lower cheek teeth is moderately developed. The lingual and buccal cingula of the lower cheek teeth are absent, except on the m3.

The i2 is huge and dagger-shaped. Its transverse section is a round triangle with an interior sharp angle, but the cross section of the root is oval. The i2 extends outward and upward.

There is no dp1 preserved.

The p2 is small and deeply worn. It has a short and narrow protolophid and a shallow ectoflexid. Its metaconid is larger than the protoconid in size. The hypolophid is wider than the entolophid, and the metolophid is wider than the protolophid. The trigonid basin is nearly disappeared, and the talonid basin is V-shaped in outline.

The p3 has a large trigonid and a relatively small talonid, a fairly short and wide protolophid, a wide metolophid, and a shallow ectoflexid. The hypolophid is wider than the entolophid. The trigonid basin is a fairly small circle, and the talonid basin is sharply V-shaped in outline, because of the deep wear.

The p4 is similar to p3, but larger.

The m1 is so deeply worn that the trigonid basin and the talonid basin are nearly disappeared, except that the talonid basin of the left m1 is still sharply V-shaped. In occlusal view, the protolophid and the hypolophid are nearly disappeared. The metolophid and the entolophid are comparatively wide. The ectoflexid is deep and sharply V-shaped.

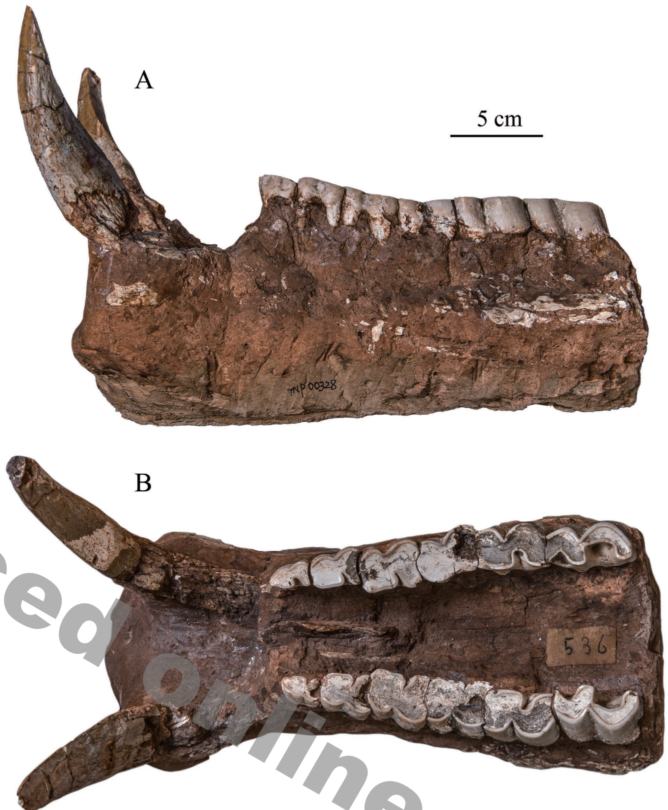

Fig. 5 The mandible of *Chilotherium licenti* sp. nov. (TNP 00328)
A. lateral view; B. occlusal view

The m2 has a round trigonid basin and a V-shaped talonid basin. The metolophid is wider. The hypolophid is oblique. The ectoflexid is deep and sharply V-shaped.

The m3 has a V-shaped trigonid basin and rectangular talonid basin. The protolophid is short and sharpens lingually. The hypolophid and the entolophid are slightly narrow. The hypolophid is comparatively oblique. The ectoflexid is wide and deeply V-shaped. The lingual cingulum is developed, but not continuous, forming a pillar at the lingual side of the talonid basin. The buccal cingulum is absent.

4 Comparison and discussion

Many characters of these specimens, particular in the mandible, are shared with species placed in *Chilotherium*. These include the gradually narrowing cranial dorsal surface before the orbits, the high position of the dorsal margin of the orbit, the strongly constricted protocones, the strongly broadening mandibular symphysis, and upturned medial flanges of i2s.

The specimens belong to a new species of *Chilotherium*, which has some special characters different from the known species of the genus.

The M3 of *C. persiae* is unique among the species of *Chilotherium* in its quadrangular occlusal surface (Ringström, 1924). Therefore, the triangular M3 of *C. licenti* distinguishes

from *C. persiae*. Meanwhile, *C. persiae* is usually larger than the Chinese specimens of *Chilotherium*, i.e., the distance between tip of the nasal and the occipital crest of an adult individual is usually ca. 630 mm. The external wall of the upper cheek teeth of *C. kiliasi* undulates with a paracone fold underlined by two depressions (Geraads and Koufos, 1990). That of *C. licenti* is flat instead. *C. schlosseri* and *C. samium* have well-developed cingula (Weber, 1904), but *C. licenti* has very reduced ones. In *Chilotherium*, the premolar series is shorter than the molar series, particularly in *C. kowalevskii* (Pavlow, 1913). The crochet on molars of *C. schlosseri* is elongate, reaching the ectoloph to form a medifossette. However, on the P2 to M2 of *C. licenti*, the crochet and crista are well-developed and link together to form a medifossette (a unique character different among the ten valid species of *Chilotherium*).

Chilotherium anderssoni, the type species of the genus *Chilotherium*, was described by Ringström in 1924. That species has a U-shaped nasal notch, a weak crochet on M3, a weak crochet and crista on P2 (not linking together to form a medifossette), and a continuous lingual cingulum on the premolars. In contract, *C. licenti* has a V-shaped nasal notch, nearly absent labial and buccal cingula on the premolars, medifossettes present from P2 to M2. *C. licenti* has a flat cranial dorsal profile, a thin dorsal orbital margin, narrow nasals, and flat outer walls of cheek teeth. Those features are obviously more derived than the characters of *C. primigenius*, *C. wimani* and *C. xizangensis*. Furthermore, *C. licenti* is somewhat larger than the three other Chinese species, which is shown in Table 1. And the measurements of the cheek teeth of *C. licenti* sp. nov. compared with other species of *Chilotherium* are shown in Table 2. The upper cheek teeth of *C. licenti* show derived characters that distinguish them from those of *C. wimani*, including a flat buccal wall almost without a paracone rib and parastyle fold, and

Table 1 Measurements of the skull of *Chilotherium licenti* sp. nov. and comparisons with other species of *Chilotherium* (mm)

Measures	*C. licenti*	*C. primigenius*[1)]	*C. xizangensis*[2)]	*C. wimani*[3)]
2 Distance between occipital condyle and nasal tip	510	–	–	530 (510–530)
4 Distance between nasal tip and bottom of nasal notch	81.3	133.5	–	143 (134–152)
9 Distance between nasal notch and orbit	72.2	55.5	54	66.1 (60–75)
13 Distance between occipital condyle and M3	283	–	–	277.8 (264–300)
14 Distance between nasal tip and orbit	210.4	186	–	210.8 (198.5–223)
18 Width between postorbital processes	203.3	147	~124	140.3(133.3–148)
19 Width between supraorbital tubercles	139.9	158	~120	157.7 (147–164.3)
20 Width between lacrimal tubercles	171.1	152	–	160.1 (152–175)
21 Maximal width between zygomatic arches	260.3	228	–	259.5 (248–265
22 Width of nasal base	89.7	83	60	87.2 (81.7–92)
25 Cranial height in front of P2	104.6	117	-	141.5 (138–158)
26 Cranial height in front of M1	108.1	138	137	171 (165–181.5)
27 Cranial height in front of M3	117	165	132	177.1 (167–189)
28 Palatal width in front of P2	46.3	42	–	46 (37.5–55.5)
29 Palatal width in front of M1	69.9	25	–	40.1 (27–57)
30 Palatal width in front of M3	78.7	28	–	54.5 (45–64)
31 Width of foramen magnum	43.3	–	–	41.3 (37.5–46)
32 Width between exterior edges of occipital condyle	121.4	–	–	112.5 (108.5–120.5)

Based on: 1) Deng, 2006; 2) Ji et al., 1980; 3) Deng, 2001a. Numbers in front of measuring method correspond to those of Guérin (1980:47, table 1).

Table 2 Measurements of the cheek teeth of *Chilotherium licenti* sp. nov. compared with other species of *Chilotherium* (mm)

	Teeth	DP1	P2	P3	P4	M1	M2	M3	p2	p3	p4	m	m2	m3
C. licenti	Length	19.4	26.6	31.3	36.1	39.9	56.7	34.3	21.8	26.6	31.5	33.5	36.6	46.9
	Width	16.5	29.9	42.1	43.1	47.0	41.6	32.7	14.2	21.4	26.9	26.3	26.9	21.9
C. primigenius[1)]	Length	–	–	–	–	29.0	33.5	36.5	19.5	26.0	28.5	26.5	32.0	37.5
	Width	–	–	–	–	51.0	51.0	45.0	13.0	21.0	24.0	26.0	29.0	25.0
C. xizangensis[2)]	Length	20.0	31.0	33.0	36.1	41.2	41.0	35.6	25.2	29.0	32.0	36.4	39.2	40.0
	Width	17.0	32.1	46.0	49.4	50.8	48.5	41.8	18.2	24.3	22.1	23.4	20.9	18.9
C. wimani[3)]	Length	15.0	25.9	31.2	34.4	38.4	48.7	48.7	23.9	29.3	35.7	39.6	46.4	46.9
	Width	18.0	34.5	49.5	56.0	59.5	61.0	56.8	17.4	20.0	25.8	27.7	28.4	25.9
C. anderssoni[4)]	Length	17.2	23.6	28.4	37.0	38.4	48.7	51.0	24.4	27.2	32.0	32.5	43.1	48.9
	Width	15.7	32.7	50.3	56.7	58.6	61.7	59.3	25.7	25.1	29.3	25.5	30.0	29.2

Based on: 1) Deng, 2006; 2) Ji et al., 1980; 3) Deng, 2001a; 4) Ringström, 1924.

strongly constricted protocones and hypocones. *C. primigenius*, an early Late Miocene species (Deng, 2006), has the primitive characters which are different from *C. licenti*. *C. xizangensis* is similar to *C. wimani*, in that they both have a saddle-backed cranial dorsal profile, projecting anterior and thick dorsal margins of the orbits, a low crown, and marked parastyle folds (Ji et al., 1980; Deng, 2001a). This new species is different from *C. habereri* evidently based on some characters on the upper cheek teeth. In *C. licenti*, the lingual and buccal cingula on premolars are nearly absent and the medifossettes are present on P2-M2. However the cingula of *C. habereri* are continuous, and there is a medifossette only on premolars, not on molars (Ringström, 1924).

Consequently, *C. licenti* is a new species different from all the known species of *Chilotherium*. This species has some unique characters. For instance, the lingual and buccal cingula are nearly absent (different from the relatively primitive species), the crochet and crista are well developed, linking together to form a medifossette on the P2 to M2, the protocone is strongly constricted. Those characters are more derived than any other known species of *Chilotherium*.

According to the diary entry of Licent (1924), the skull articulated with its atlas and the mandible were found in the same place. Based on our observations and measurements, the degree of wear of the upper cheek teeth is much less than the lower ones, and the length of the upper cheek tooth row is 190 mm but that of the lower is 200 mm. The comparison between crown heights of the upper and lower cheek teeth is shown in Table 3. Given that the speed of wear on upper cheek teeth is much faster than that of the lower cheek teeth in an individual of the genus *Chilotherium* (Deng, 2001b), the skull and mandible unlikely belong to one individual, and probably represent two adult individuals (thus are given two specimen

Table 3 The comparison between crown heights of the upper and lower cheek teeth of *Chilotherium licenti* sp. nov. (mm)

Teeth	DP1	P2	P3	P4	M1	M2	M3
Crown height	8.1	17.6	19.1	23.1	17.7	34.5	42.5
Teeth		p2	p3	p4	m1	m2	m3
Crown height		13.5	11.3	11.4	16.4	21	21.9

numbers). Ringström (1924) insisted that an isolated dentition from a member of the genus *Chilotherium* cannot be easily identified. The new mandibular specimen differs from the other species of *Chilotherium*, but the skull and mandible were found in the same place. Therefore, we attribute the mandibular specimen to *C. licenti.*

Cingula tending to be absent and the high and flat crown surface indicate that *C. licenti* may remain brush feeders but with an increasing adaptation to hard and dry bush vagatation. The well-developed secondary structures on the cheek teeth and the increased molar crown height are all indicators of a shift towards a more abrasive diet. We infer that the Late Miocene rhino *C. licenti* grazed in an open steppe habitat. In order to adapt to the drought environment of the Late Miocene (Deng, 2004), it appears that *C. licenti* developed some derived features.

This new Late Miocene species shares many characters with the other species of *Chilotherium*. Among its characters, *C. licenti* displays a highly specialized morphotype of the genus *Chilotherium*. Compared with *C. anderssoni* and *C. habereri*, *C. licenti* is characterized by a V-shaped nasal notch, nearly absent buccal and lingual cingula, a medifossette on P2-M2 formed by the well-developed crochet and crista, a metaloph constriction on P2-P4, and the base of the antecrochet spreading toward the entrance of the median valley. Those characters are more derived than those of *C. anderssoni* and *C. habereri*. Heissig (1989) considered that *Chilotherium* emerged during the early Middle Miocene of South Asia with *Subchilotherium* from the lower Siwalik series. *C. primigenius* is the earliest and most primitive species in the genus *Chilotherium* from the early Late Miocene, corresponding to the early and middle MN 9 (Deng, 2006). *Chilotherium wimani* was the most abundant taxon in the Late Miocene "*Hipparion* fauna" of the Linxia Basin, the first appearance of *C. wimani* was necessarily later than that of *C. primigenius*, and must precede that of the other species of *Chilotherium* (Deng, 2006). The type species of the genus *Chilotherium*, *C. anderssoni*, is abundant in Baode fauna correlated to MN12. Liu et al. (1978) reported that *C. habereri* is present in the (Miocene) Gongwangling locality (Lantian, Shaanxi) attributed to an age of 6.6 Ma (Zhang et al., 2013). In conclusion, the first appearance of *C. licenti* is correlated to MN12-13 of the Turolian in Europe.

The Qingyang *Hipparion* fauna contains abundant fossils including those of *H. hippidiodus* and *H. coelophyes*. Comparing with the *Hipparion* species at Baode, *H. hippidiodus* and *H. coelophyes* of Qingyang *Hipparion* fauna are likely more derived as indicated by their smaller body size, the reduced preorbital fossa, and other features (Qiu et al., 1987). Qiu et al. (1979) have systematically studied the late Late Miocene hyaenids, including *Adcrocuta eximia variabilis*, *Ictitherium robustum gaudryi*, *I. wongii* and other species which were collected by Emile Licent in Xinjiagou and Zhaojiacha (Qingyang, Gansu) in 1920. Given those shared species, the Qingyang *Hipparion* fauna has been correlated to MN12 (Qiu and Qiu, 1990). Therefore, the earliest possible date of *C. licenti* is correlated to MN12 of the Turolian in Europe, and *C. licenti* from the late Late Miocene is the most derived species in the genus *Chilotherium* described so far.

6 Phylogenetic analysis

We performed a phylogenetic analysis to assess the phylogenetic position of *Chilotherium licenti* using the data matrix of Lu (2013, Appendix A-2), with addition of the new species (Appendix 1). The matrix includes 23 taxa and 214 characters (Fig. 6). In order to guarantee the availability of data, we deleted some taxa in the data matrix of Lu (2013), such as "*Aceratherium*" *huadeensis* and other materials which are poorly preserved or taxonomically in controversial. Meanwhile, the type species of the genus *Chilotherium*, *C. anderssoni*, has been retained, and the earliest and most primitive species, *C. primigenius*, was added. *Trigonias osborni* served as the outgroup for our analyses. The phylogenetic analysis was performed using traditional search under TNT (Version 1.1) (Goloboff et al., 2008), with all characters equally weighted. The analysis generated one most parsimony tree with a tree length of 620 steps, a consistency index of 0.355, and a retention index of 0.524.

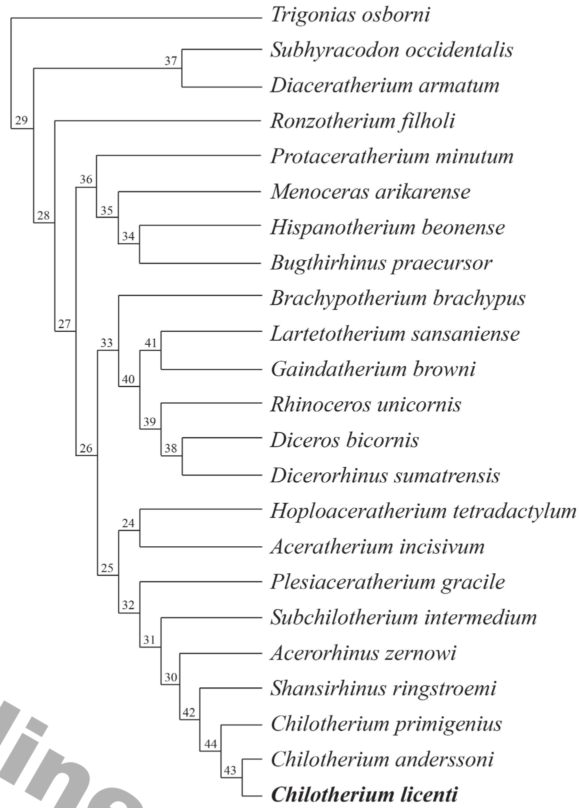

Fig. 6 Tree of traditional search performed with ordered multistate characters

Chilotherium licenti shares many synapomorphies with the other species in the genus including a narrow zygomatic arch, a gradually narrowing cranial dorsal surface rostral to the orbit, a strong broadening of the mandibular symphysis, well-developed secondary structures on the cheek teeth, a comparatively small P2, and upturned medial flanges of i2. Those features support that *C. licenti* is a member of the genus *Chilotherium*. *Chilotherium licenti* is the sister taxon of *C. anderssoni*, and both of them are more derived than *C. primigenius*. In *C. primigenius*, the ventral surface of the mandibular symphysis is flat, and the parietal crests are not well separated and form a sagittal crest, differing from other species (Deng, 2006). Meanwhile, *C. licenti* is characterized by the medifossette from P2 to M2 forming by the well-developed crochet and crista, and the nearly absent lingual and buccal cingula, which are different from other *Chilotherium* species.

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甘肃庆阳晚中新世大唇犀属(奇蹄目，犀科)一新种

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摘要：报道并描述了大唇犀属一新种——桑氏大唇犀(*Chilotherium licenti* sp. nov.), 材料为桑志华于1920年在甘肃庆阳晚中新世地层中采集到的一件关联寰椎的成年头骨和一件成年下颌骨。新种除了具有下颌联合部强烈扩展，i2巨大且内刃上翻，原尖收缩强烈，前刺和小刺发育，前附尖褶和前尖肋微弱等大唇犀属的典型特征之外，还具有前刺和小刺发育并连接形成中凹(P2–M2), 内外齿带退化等特征。新种的进步特征显示其属于大唇犀属内高度特化的类群。新种时代属于保德期，对应于欧洲的MN12–13。根据形态特征对比以及系统发育分析，推断来自晚中新世的桑氏大唇犀是大唇犀属内最进步的类群。

关键词：甘肃庆阳，晚中新世，犀科，大唇犀属

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Supplementary material can be found on the website of Vertebrate PalAsiatica (http://english.ivpp.cas.cn/sp/PalAsiatica/vp_list/) in Vol. 56.

Appendix 1 Character codes of *Chilotherium licenti* and characters are after Lu (2013).

Chilotherium licenti (TNP 03978)							
0011111110	-000011000	10?01?????	??0?100000	0-0-0-01??	??0?0?????	????11???	121???????
0???001001	1?1-1111-0	1111102000	1220121232	-010-10033	1103130231	3222310111	112100000?
-0112?1110	1?10?0013-	1-??0?102-	3-1011????	??????0???	????		